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11 Publication number:

0 291 170
A1

12

EUROPEAN PATENT APPLICATION

23 Application number: 88303294.8

51 Int. Cl. 4: A61B 17/22, A61B 17/32

22 Date of filing: 13.04.88

30 Priority: 17.04.87 US 39346

43 Date of publication of application:
17.11.88 Bulletin 88/46

84 Designated Contracting States:
CH DE FR GB IT LI SE

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54 Rearwardly acting surgical catheter.

57 A surgical catheter (10) is disclosed, comprising a distal end (20) for advancing into a blood vessel at a single incision remote from occlusions, a proximal end (16, 18) for manipulating the catheter *ex vivo*, a body portion (23) connecting the two ends, and means (40) adjacent the distal end for cutting away such occlusions while the distal end is far removed from the incision, the cutting means (40) including at least a movable cutting edge (56). The catheter (10) is improved in that the movable cutting edge (56) is disposed so that it faces rearwardly, towards the body portion (23). Further there is included means (48) for moving the cutting edge (56) rearwardly to cut tissue or fatty deposits towards the catheter body portion (23) and the remote incision.

Such a catheter (10) is used in a surgical method such that the cutting means (40) is activated to cut the fatty deposits only in a rearward direction towards the incision, instead of in an advancing direction.

EP 0 291 170 A1

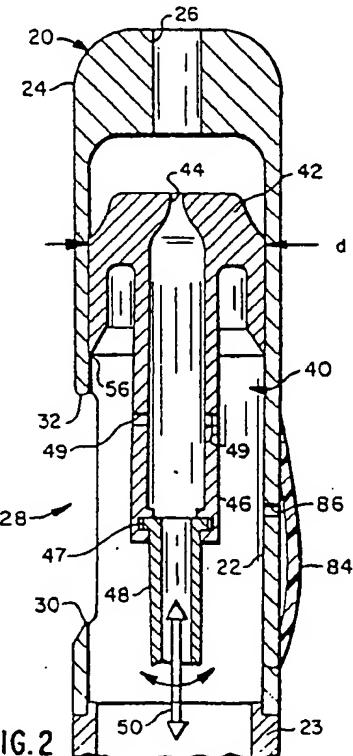


FIG.2

REARWARDLY ACTING SURGICAL CATHETER

This invention relates to surgical catheters used to cut and remove obstructions in vessels such as arteries and the like, by being inserted into incisions that are remote from the obstructions.

Cutting catheters are known in the art, in which an arterial or endarterectomy catheter has at its distal end, a cutting surface that cuts away fatty deposits. Invariably, however, such catheters cut while being pushed forward. Examples of such catheters are shown in the following: U.S. Pat. Nos. 3,448,741; 4,273,128; and 4,512,344. A disadvantage with such devices is that the continued removal of material in front of the catheter can lead to a build-up of debris that clogs the artery or catheter, so as to render further progress difficult. Another disadvantage is that cutting catheters that cut while advancing, occasionally run into curvatures in the vessel wall that cause the cutting surface to injure the vessel inadvertently. Even if a shield is provided in front of the cutting means, the primary problem is that when the cutting means cuts towards the shield, but builds up deposits within the catheter, requiring repeated withdrawal for cleaning.

In accord with one aspect of the invention the problems noted above have been addressed by a surgical catheter comprising a distal end for advancing into a blood vessel at a single incision remote from occlusions, a proximal end for manipulating the catheter *ex vivo*, a body portion connecting the two ends, and means adjacent the distal end for cutting away such occlusions while the distal end is at a location removed from the incision, the cutting means including at least a movable cutting edge; characterized in that the movable cutting edge is disposed so that it faces rearwardly, towards the body portion, and also in that there is further included means for moving the cutting edge rearwardly to cut tissue or fatty deposits towards the body portion and the remote incision.

In accord with a further aspect of the invention, the above-noted problems are addressed by a method for removing fatty deposits from occlusions in blood vessels using a catheter having a distal end, a proximal end, a body portion connecting the ends, and cutting means on the distal end for cutting away the fatty deposits. The method comprises the steps of forming an incision in such blood vessel at a location remote from such occlusions, inserting said distal end and body portion into the incision, advancing the distal end and body portion towards an occlusion while retaining the proximal end *ex vivo*, positioning the distal end over such occlusion, and pulling one of the cutting means rearwardly towards the body portion to cut

the occlusion.

Thus it is an advantageous feature of the invention that the catheter cuts loose the fatty deposits in a direction that favors withdrawal of them out of the artery. This avoids a build-up of deposits in the catheter that can occur if the cutting action is in the opposite direction, as provided in certain prior catheters.

It is a related advantageous feature of the invention that such a catheter need not be withdrawn after just a few cuts, because the distal end has not become clogged with deposits.

The present example will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of the use of a catheter constructed in accord with the invention, to cut away deposits at locations remote from the incision used to insert the catheter;

Figure 2 is a section view of the distal end of the catheter illustrating its inventive features; and

Figure 3 is a section view similar to that of Figure 2, but of an alternate embodiment.

The invention is described hereinafter in connection with its use in cutting away fatty deposits in an artery, a preferred embodiment. In addition, the invention is useful in catheters used to cut away thickened atheromatous tunica intima, usually fatty deposits, of any body channel, whether or not it is an artery.

Figure 1 illustrates the manner in which a catheter 10 constructed in accordance with the invention is inserted in an incision 12 in a patient's body, and pushed along an artery such as the femoral artery until it reaches an occlusion, here shown as being in the coronary artery C. That occlusion is remote from the incision, as is the distal end 20 of the catheter. Control of the catheter is achieved *ex vivo* by control means 16, as is conventional.

Distal end 20 Figure 2, comprises a cylindrical tube 22 connected in a conventional manner to a flexible body portion 23 of the catheter (which extends back to the incision and to control means 16), and a movable member 40 mounted within tube 22 for movement relative to the tube. To protect the vessel walls while the catheter is advancing through the curvilinear body vessel, tube 22 further preferably comprises shield portion 24 apertured at 26 for additional features hereinafter discussed, and cutting aperture 28. Such aperture has a cutting edge 30 that faces forwardly towards the shield portion. Opposite edge 32 of aperture 28 is either a sharp cutting edge, or it can be blunt, since it does not cooperate with the moving member 40 for a shearing action.

Member 40 comprises an end portion 42 having an exterior diameter "d" that permits a sliding fit within the interior walls of cylindrical tube 22, and a hollow interior passageway 44. That passageway is part of a sleeve 46 that has reduced exterior diameter compared to diameter d. Sleeve 46 is then connected at 47 to a hollow tube 48 that extends all the way back through body portion 23 of the catheter. Tube 48 is hollow to allow the flow of, e.g., blood through the catheter and hence through the artery during the operation. Openings 49 are provided in sleeve 46 for aiding in removing cut material. Tube 48 and its connected sleeve 46 and end portion 42 are moved relative to tube 22, (arrow 50) either in a reciprocating fashion, a rotating fashion, or both, by hand or by a conventional, preferably reciprocating, motor in control means 16, Figure 1.

To provide shearing action to the distal portion 20, end portion 42 terminates in an annular cutting edge 56 that faces only rearwardly and which cooperates with stationary cutting edge 30 to shear off fatty deposits that get caught in aperture 28. Edge 56 is the active cutting edge, since without it edge 30 does substantially no cutting, as is intended. Member 40 acts to cut while it is being pulled rearwardly, so that the cut fatty deposits are directed rearwardly towards body portion 23. To assist in the steady removal of the cut deposits, a wash liquid preferably is pumped towards distal end 20 through tube 48. It exits at apertures 49. (If necessary, aperture 44 can be eliminated to insure flow out of apertures 49). At the same time, a suction is applied from control 16 to pull liquid and the cut debris down towards the incision, through the body portion 23. During the phase of the operation, the patient's blood will not flow through the tube 48 or body portion 23, but it is conventional for the catheter diameter to permit blood flow around the outside.

Optionally, a conventional balloon 84 can be mounted on the side of tube 22 opposite to aperture 28, to be expanded by a liquid delivered out through aperture 86 from a feeder line, not shown. Such a balloon is used to push distal end 20 towards the occlusion so that aperture 28 surrounds a portion of it.

Shield aperture 26 can be used to allow blood to continue flowing through the artery, or it can be used for flexible probe (not shown) that extends beyond shield 24, particularly if greater flexibility is desired than is possible with distal portion 20. Alternatively, it can be used for injection of a dye that is sent down the catheter from a syringe 18, Figure 1, through the hollow tube 48.

In the alternative embodiment of Figure 3, the cutting edge of the moving part need not be annular as in the previous embodiment. Part similar

to those previously described bear the same reference numerals to which the distinguishing suffix "a" is appended. Thus, distal portion 20a comprises shield 24a, aperture 28a, and cutting edge 30a, constructed as in the previous embodiment. However, cutting edge 56a is formed so as to have a spiral locus, measured from end surface 100 of end 42a of member 40a, that is continuously variable around the circumference of edge 56a. This shape provides greater shearing as member 40a is reciprocated (arrow 50a) relative to tube 22a. (Preferably, member 40a is not rotated). As in the previous embodiment, cutting occurs only in a direction towards the incision.

In use, the catheter is controlled at the proximal end *ex vivo*, as is conventional. The distal end is pushed to the occlusions to be operated on, preferably while member 40 is pulled back to a position blocking aperture 28, to shield edge 30 from snagging on the vessel wall. Then end 20 is moved over against an occlusion while member 40 is pushed forwardly, opening up aperture 28. When a part of the occlusion is projecting into aperture 28, member 40 is reciprocated so that it cuts (shears) back towards the incision to cause severing of fatty deposits. These deposits are then pulled rearwardly out body portion 23, with or without the aid of a wash liquid.

Techniques such as control of bleeding are readily achieved by conventional methods, some of which are discussed in, e.g., U.S. Pat. No. 4,273,128.

Because of the invention, buildup of removed fatty deposits does not occur when using this catheter. Furthermore, removal of such severed parts is readily achieved.

Claims

- 40 1. A surgical catheter comprising a distal end for advancing into a blood vessel at a single incision remote from occlusions, a proximal end for manipulating the catheter *ex vivo*, a body portion connecting the ends, and means adjacent said distal end for cutting away such occlusions while said distal end is at a location removed from the incision, said cutting means including at least a movable cutting edge;
- 45 50 characterized in that said movable cutting edge is disposed so that it faces rearwardly, towards said body portion;
- 55 and further including means for moving said cutting edge rearwardly to cut tissue or fatty deposits towards the body portion and the remote incision.

2. A catheter as defined in claim 1, and further including shield means in front of said cutting edge to shield tissue from contacting said cutting edge while said distal end is being advanced through the artery away from the incision.

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3. A catheter as defined in claim 1 or 2, and further including a stationary cutting edge and means for reciprocating said movable cutting edge relative to said stationary cutting edge.

4. A catheter as defined in claim 1, 2 or 3, wherein said moving means includes means for reciprocating said cutting edge.

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5. A method for removing fatty deposits from occlusions in blood vessels using a catheter having a distal end, a proximal end, a body portion connecting said ends, and cutting means on said distal end for cutting away such fatty deposits;

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the method comprising the steps of forming an incision in such blood vessel at a location remote from such occlusions.

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inserting said distal end and body portion into the incision,

advancing said distal end and body portion towards such occlusion while retaining said proximal end ex vivo,

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positioning said distal end over an occlusion, and pulling one of said cutting means rearwardly towards said body portion to cut said occlusion.

6. A method as defined in claim 5, and further including the step of removing fatty deposits cut from said occlusion, out through said body portion.

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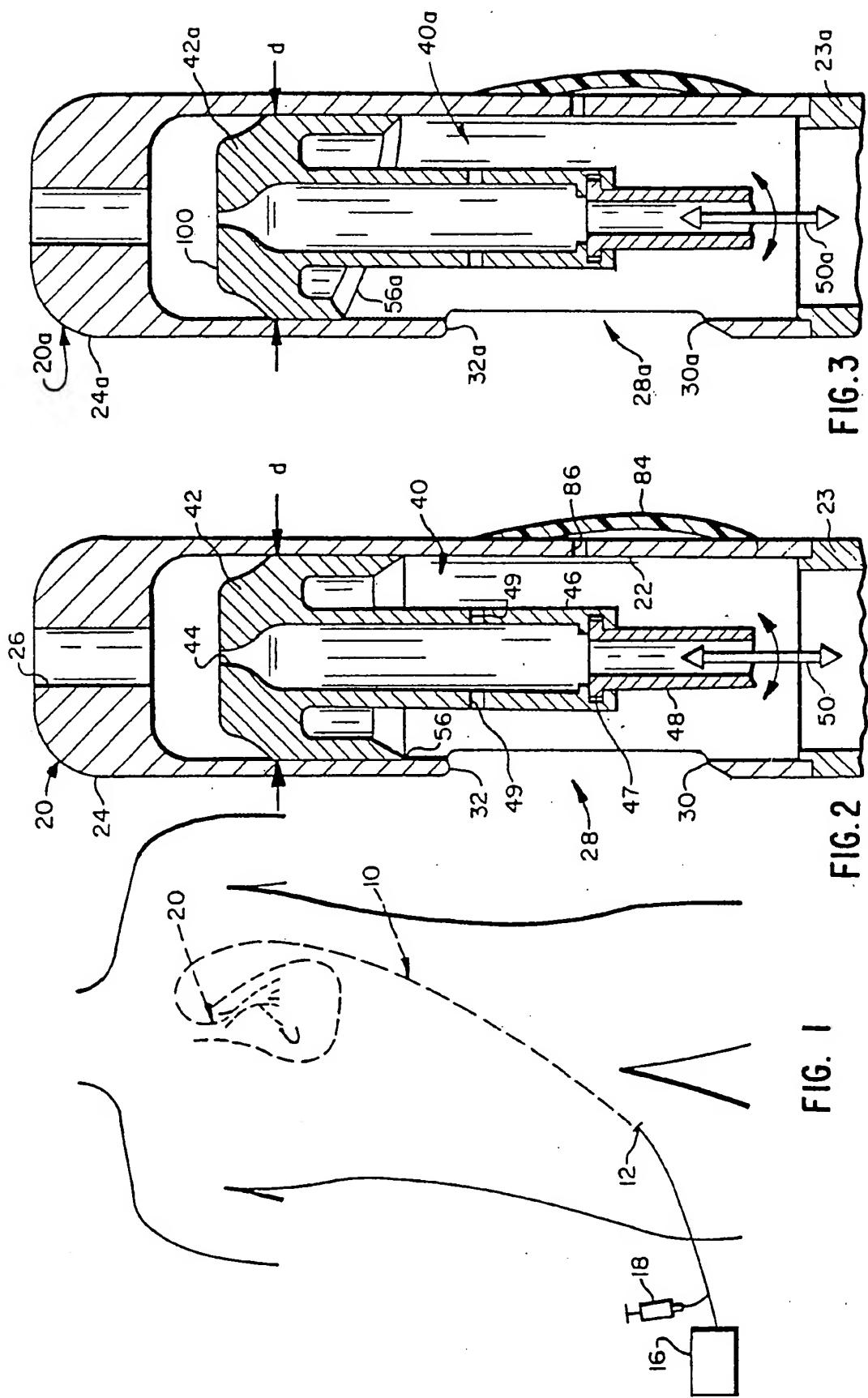
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PARTIAL EUROPEAN SEARCH REPORT
which under Rule 45 of the European Patent Convention
shall be considered, for the purposes of subsequent
proceedings, as the European search report

Application number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 88303294.8
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y, P	EP - A1 - 0 238 217 (DEV.F.VASC. INTERV.) * Totality; especially fig. 1A,1B page 3, line 1 - page 5, line 9; page 6, line 28 - page 7, line 2; page 7, line 18 - page 8, line 16 * --	1-4	A 61 B 17/22 A 61 B 17/32
Y	US - A - 4 620 547 (M.BOESEL) * Fig. 1,2; column 2, lines 18-66 * --	1-4	
Y	US - A - 3 173 414 (A.GUILLANT) * Fig. 1; column 1, lines 11-33 * --	1-4	
A	GB - A - 2 044 103 (D.N.ROSS) * Fig.; abstract; page 1, lines 117-124; page 2, lines 15-69 * --	1,3,4	
INCOMPLETE SEARCH			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			A 61 B 10/00 A 61 B 17/00 A 61 M 25/00
Place of search VIENNA		Date of completion of the search 12-08-1988	Examiner LUDWIG
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			



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PARTIAL EUROPEAN SEARCH REPORT

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
D,A	US - A - 4 273 128 (B.G.LARY) * Fig. 1,9,10; column 4, line 55 - column 5, line 9 * -----	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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